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# *Advanced Heterogeneous Reburn Fuel From Coal and Hog Manure*

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# *Research Rationale*

- Animal waste can be converted to an organic material that can be transported from a farming operation to a coal-fired power plant.
- At the power plant, the organic material could be combined with pulverized coal or coal fines to form a reburn fuel used to reduce the concentration of  $\text{NO}_x$  leaving the system.

# *Advanced Reburning*

- Combines basic reburning with the injection of ammonia or urea and alkali promoter compounds.
- Has been shown to reduce  $\text{NO}_x$  emissions by 85% to 95% at a heat input of 10%.

# *Project Goal*

To determine if heterogeneous reburn fuel from processed hog manure and pulverized coal might result in advanced reburning without the addition of either alkali or ammonia/urea.

# *Project Objectives*

- Process hog manure in an autoclave at elevated temperature and pressure.
- Combine the resulting organic material with pulverized coal to make a heterogeneous reburn fuel.
- Evaluate the  $\text{NO}_x$ -reducing ability of the heterogeneous reburn fuel.

# *Hog Manure*

Fresh hog manure was acquired from EnviroPork, a 5000-sow operation the produces 110,000 piglets each year and is located about 30 miles from the EERC.

# *Dried Raw Hog Manure*



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# *Raw Hog Manure Proximate Analysis (air dried)*

Moisture, wt%	10.53
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Volatiles, wt%	53.22
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Fixed C, wt%	10.05
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Ash, wt%	26.18
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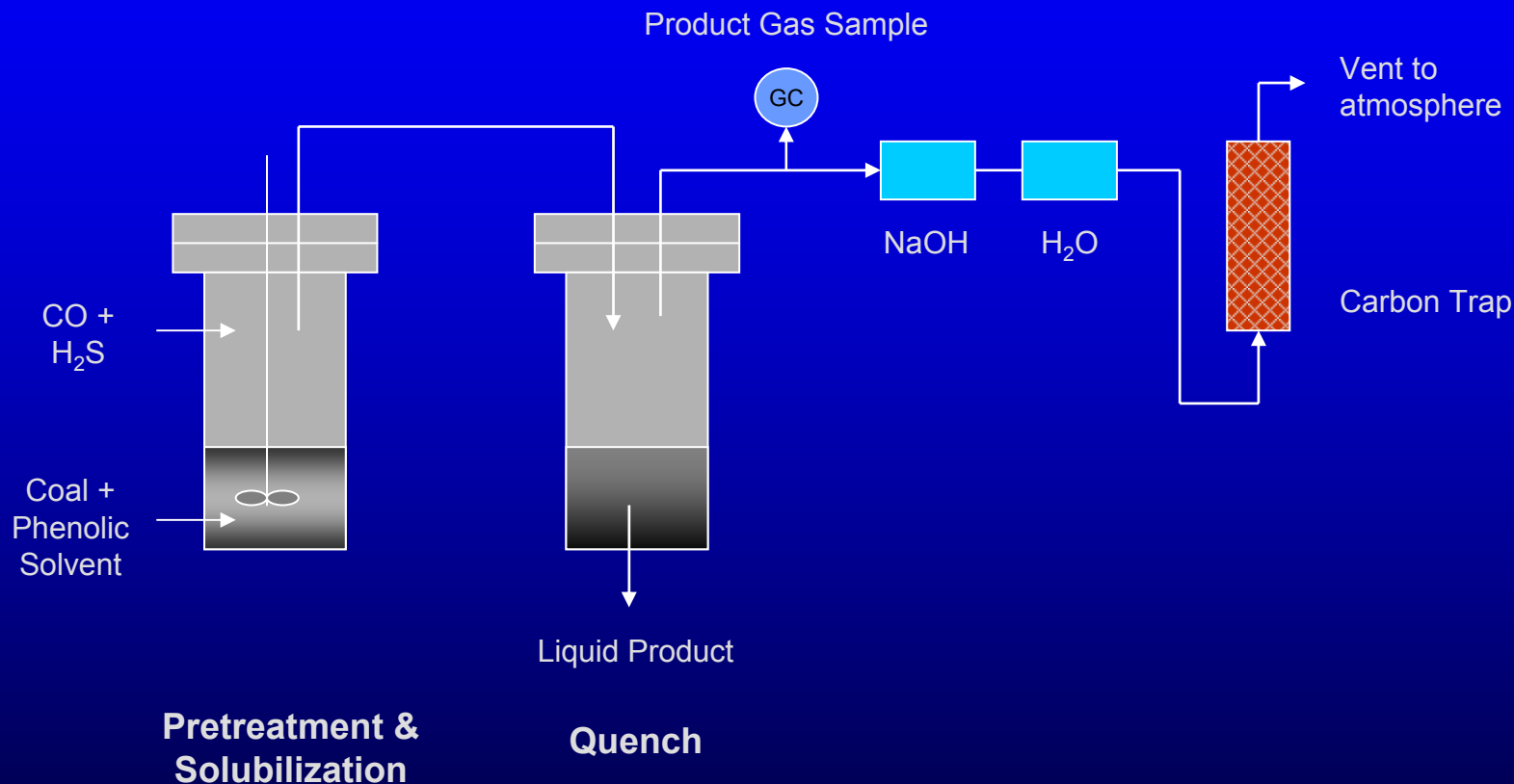
Heating Value, kJ/kg	14,511
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# *Raw Hog Manure Ultimate Analysis (dry basis)*

C	36.97
H	4.29
N	3.46
S	0.58
O	25.43
Ash	29.26

# *EERC's Cold-Charge Autoclave System*





# *Processing Procedure*

- Water was added to bring the hog manure moisture content to 80 wt%.
- Alkali reaction promoter was added at a rate of 5 wt% of moisture- and ash-free (maf) manure.
- The autoclave was purged with  $N_2$ .
- CO was added at a rate of 10 gmol per 200 g maf manure.
- The system was heated to 275°C, held for 20 min, and cooled overnight.

# *Results of First Processing Test*

- The first test test was performed at 300°C.
- The stirrer disconnected during the test.
- The products consisted of a char-like solid and a heavy-oil foam.

# *Results of Subsequent Tests*

- The remaining three tests were performed at 275°C to avoid coking reactions.
- The product of each consisted of an oil-containing solid, an aqueous liquid stream, and gas. Heavy-oil foam was not noted in any of these tests.



# *Solid Products*



Run 2



Run 3



Run 4



# *Product Slate*

	Run 2	Run 3	Run 4
Mass Balance, %	95.49	94.77	93.46
Solid, wt% maf manure	55.4	53.4	70.5
Aqueous Liquid, wt% maf manure	0.3	0.3	0.2
Gas, wt% maf manure	44.3	46.6	29.3



# *Solid Product Proximate Analysis*

	Run 2	Run 3	Run 4	Composite
Moisture, wt%	0.43	0.89	2.21	2.21
Volatiles, wt%	41.45	49.11	44.67	46.98
Fixed C, wt%	13.47	7.66	6.46	7.21
Ash, wt%	44.64	42.34	46.64	43.60
Heating Value, kJ/kg	18,647	Not Analyzed	17,920	19,171

# *Solid Product Ultimate Analysis*

## *(dry basis)*

	Test 2	Test 3	Test 4	Composite
C	41.51	44.72	38.94	39.96
H	4.95	6.10	4.78	5.04
N	2.10	2.30	2.04	2.03
S	0.71	0.00	0.61	0.58
O	5.89	4.16	5.93	7.81
Ash	44.83	42.72	47.70	44.58

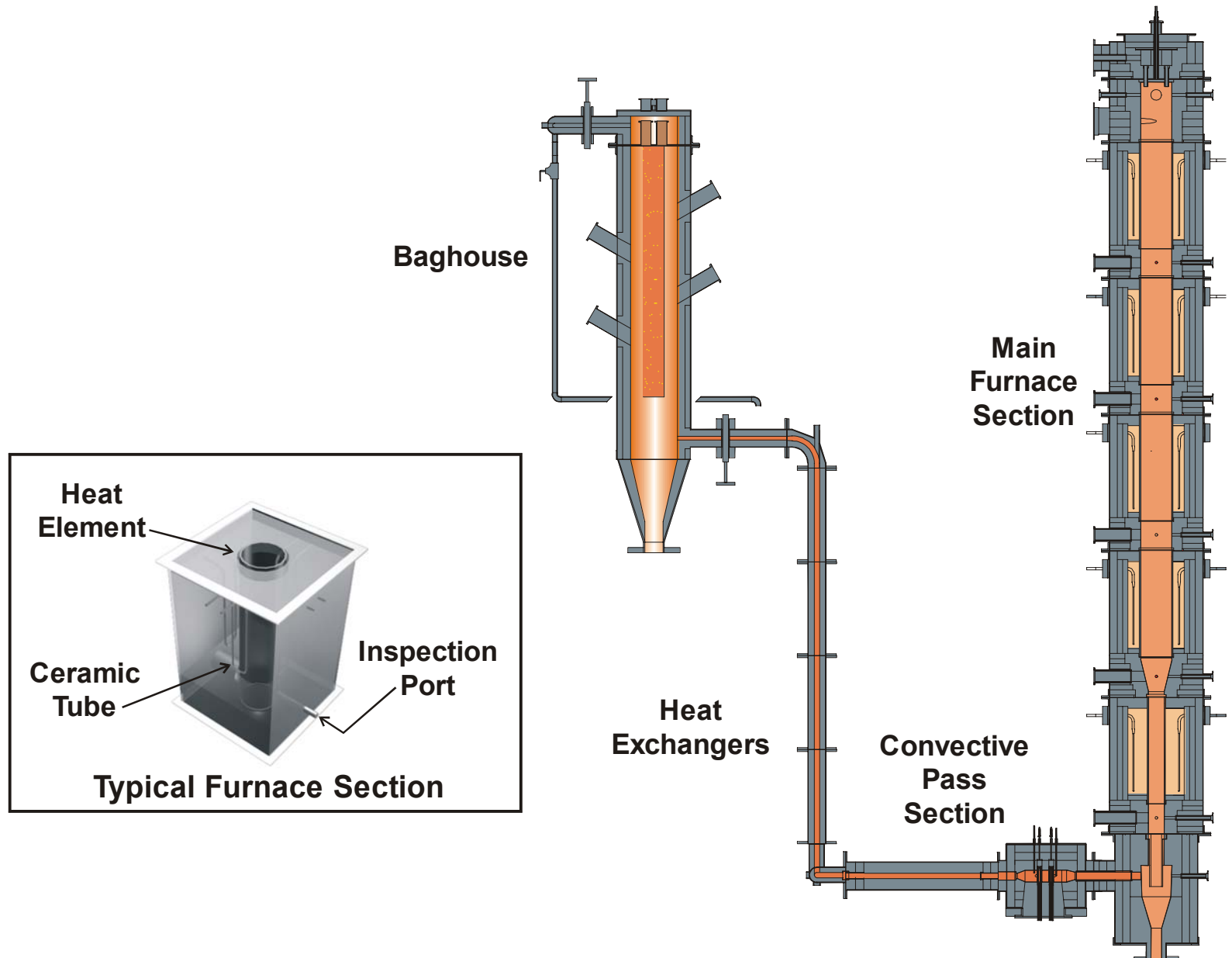
# *Reburn Tests*

- Two tests will be performed in the EERC's combustion and environmental process simulator (CEPS)
  - 15 wt% pulverized lignite and 85 wt% processed hog manure
  - 15 wt% pulverized lignite and 85 wt% dried raw hog manure
- Mixtures will be fed at a reburn heat input of 10%

# *Combustion and Environmental Process Simulator*

- Nominally 1.8 kg/hr, downfired combustion system designed to generate realistic combustion test results for a variety of fuels and conditions.
- On-line gas analyzers will monitor O<sub>2</sub>, CO, CO<sub>2</sub>, SO<sub>2</sub>, and NO<sub>x</sub> levels (including both thermal and fuel NO<sub>x</sub>).

# Conversion and Environmental Process Simulator



# Comparison to Other Reburn Fuels

(Maly, et al.)

	Biomass	CRDF	Coal Fines	Manure Composite
C	48.89	68.40	73.44	39.96
H	5.75	7.70	4.45	5.04
N	0.53	0.40	1.28	2.03
S	0.05	0.60	2.86	0.58
O	40.29	9.70	5.44	7.81
Ash	4.79	8.00	12.53	44.58
NO <sub>x</sub> Reduction	50%	50%	44%	
AR	90%	75%	70%	
Promoted AR	96%	94%	78%	

# *Summary*

- Hog manure was processed in an autoclave at elevated temperature and pressure.
- The composite product of three runs has a heating value of 19,171 kJ/kg.
- The NO<sub>x</sub>-reducing ability of the processed hog manure–pulverized coal heterogeneous reburn fuel will be evaluated this summer.

# *Acknowledgement*

This work is being performed under DOE Agreement No. DE-FG26-02NT41551 as part of the Department's Support of Advanced Coal Research at U.S. Colleges and Universities.